higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N5

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This marking guideline consists of 11 pages.

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QUESTION 1: POWER TRANSMISSION

1.1 $$\theta = \frac{584 \times T_{max} \times L}{G \times d_s^4}$$

$$T_{max} = \frac{\theta \times G \times d_s^4}{584 \times L} \checkmark$$

$$T_{max} = \frac{1{,}8 \times 85 \times 10^9 \times 0{,}06^4}{584 \times 1.55} \checkmark$$

$$T_{max} = 2190.544\ N.m$$

$$T_{max} = \boxed{2{,}191\ kN.m} \checkmark$$

$$T_{shaft} = \frac{\pi}{16}\tau d^3$$

$$\tau = \frac{16T}{\pi \times d^3}$$

$$\tau = \frac{16(2{,}191 \times 10^3)}{\pi \times (0{,}06)^3} \checkmark$$

$$\tau = \boxed{51.661\ MPa} \checkmark \quad (5)$$

1.2 $$P = \frac{2\pi NT}{60}$$

$$P = \frac{2\pi(900)(2{,}191 \times 10^3)}{60} \checkmark$$

$$P = 206496{,}885\ W$$

$$P = \boxed{206{,}497\ kW} \checkmark \quad (2)$$

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QUESTION 2: RIVERTED JOINTS

2.1 $Data:\ w = 240\ mm;\ t = 20\ mm\ ;\ t_{cover} = 15\ m;\ \ d = 30\ ;\ \sigma_t = 73\ MPa;$
$\sigma_c = 118\ MPa\ ;\ \tau = 58\ MPa$

<u>For tearing</u>

$$F_t = \sigma_t(w - d)t$$

$$F_t = 73 \times 10^6(0{,}24 - 0{,}03)0{,}02 \checkmark$$

$$F_t = \boxed{306{,}6\ kN} \checkmark$$

For shearing

$F_s = \tau\left(\frac{1}{4}\pi d^2\right)n \times 1{,}75$

$F_s = 58 \times 10^6\left(\frac{1}{4}\pi \times 0{,}03^2\right)6 \times 1{,}75$✓

$F_s = \boxed{430{,}477\ kN}$✓

For crushing

$F_c = \sigma_c dtn$

$F_c = 118 \times 10^6(0{,}03)(0{,}02)(6)$✓

$F_c = \boxed{424{,}8\ kN}$✓

$Safe\ load\ is\ F_t = \boxed{306{,}6\ kN}$✓ (7)

2.2 $F_t = \sigma_t(w-d)t$

$\sigma_t = \frac{F_t}{(w-d)t}$✓

$\sigma_t = \frac{306{,}6 \times 10^3}{(0{,}24-0{,}03)0{,}02}$✓

$\sigma_t = \boxed{73\ MPa}$✓ (3)

2.3 $F_s = \tau\left(\frac{1}{4}\pi d^2\right)n \times 1{,}75$

$\tau = \frac{F_t}{\left(\frac{1}{4}\pi d^2\right)n \times 1{,}75}$✓

$\tau = \frac{4(306{,}6 \times 10^3)}{(\pi 0{,}03^2)6 \times 1{,}75}$✓

$\tau = \boxed{41{,}31\ MPa}$✓ (3)

2.4 $F_c = \sigma_c dtn$

$\sigma_c = \frac{F_t}{dtn}$✓

$\sigma_t = \frac{306{,}6 \times 10^3}{0{,}03(0{,}02)(6)}$✓

$\sigma_t = \boxed{85{,}17\ MPa}$✓ (3)

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QUESTION 3: KEYS AND SPLINES

DATA: d = 45 mm; T = 700 Nm; $\sigma_c/\sigma_t = 110\ MPa;\ \tau = 60\ MPa$
From the table *(Use the safe values)* $w = 14\ mm$ ✓
$t = 9\ mm$ ✓ (2)

3.2 For Shearing

$Torque\ on\ shaft = Torque\ on\ key\ due\ to\ shear$

$Torque\ on\ shaft = w \times l \times \tau \times \frac{d}{2}$

$700 = 0{,}014 \times l \times 60 \times 10^6 \times \frac{0{,}045}{2}$ ✓

$l = \dfrac{700 \times 2}{0{,}014 \times 60 \times 10^6 \times 0{,}045}$

$l = 0{,}03704\ m$

$\boxed{l = 37{,}04\ mm}$ ✓

For Crushing

$Torque\ on\ shaft = Torque\ on\ key\ due\ to\ crushing$

$T = \frac{t}{2} \times l \times \sigma_c \times \frac{d}{2}$

$700 = \frac{0{,}09}{2} \times l \times 110 \times 10^6 \times \frac{0{,}045}{2}$ ✓

$l = \dfrac{700 \times 2 \times 2}{0{,}09(110 \times 10^6)(0{,}045)}$

$l = 0{,}006285\ m$

$\boxed{l = 6{,}29\ mm}$ ✓

Use length is equal to 37,04 mm ✓ (5)

QUESTION 4: COTTERED JOINT

4.1 $F = 2bt\tau$

$F = 2(0{,}055)(0{,}018)(48 \times 10^6)$✓

$F = \boxed{95{,}040\ kN}$✓ (2)

4.2 $F = \frac{\pi}{4} d^2 \sigma_t$

$d = \sqrt[2]{\frac{4F}{\pi(\sigma_t)}}$✓

$d = \sqrt[2]{\frac{4(95040)}{\pi(50 \times 10^6)}}$✓

$d = 0{,}0492$ m

$d = 49{,}2\ mm$✓

$Use\ d = \boxed{50\ mm}\ (Std\ size)$✓ (4)

4.3 <u>Considering tearing</u>

$95040 = \left[\frac{\pi}{4} {d_1}^2 - (d_1 \times t)\right] \sigma_t$

$95040 = \left[\frac{\pi}{4} {d_1}^2 - (d_1 \times 0{,}018)\right] 50 \times 10^6$✓

$\left[0{,}785 {d_1}^2 - 0{,}018 d_1\right] = 19{,}008 \times 10^{-4}$✓

$\left[0{,}785 {d_1}^2 - 0{,}018 d_1\right] - 19{,}008 \times 10^{-4} = 0$✓

$d_1 = \frac{-\mathrm{b} \pm \sqrt{\mathrm{b}^2 - 4\mathrm{ac}}}{2\mathrm{a}}$

$d_1 = \frac{-(-0{,}018) \pm \sqrt{(-0{,}018)^2 - 4(0{,}785)(-19{,}008 \times 10^{-4})}}{2(0{,}785)}$✓

$d_1 = \frac{0{,}018 \pm 0{,}0793}{1{,}57}$✓

$d_1 = 0{,}06197\ m$

$d_1 = 61{,}97\ mm$

$Use\ the\ prefered\ value\ \ d_1 = \boxed{65\ mm}\ \ (Std\ size)$ ✓

Considering crushing

$F = d_1 t \sigma_c$

$d_1 = \frac{F}{t\sigma_c}$

$d_1 = \frac{95040}{(0{,}018)(86 \times 10^6)}$ ✓

$d_1 = 0{,}06139$

$d_1 = 61{,}39\ mm$✓

$Use\ d_1 = \boxed{65\ mm}$

$Choose\ \ d_1 = \boxed{65\ mm}$✓ $\ (Std\ size)$ (9)

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QUESTION 5: FLANGE COUPLING

5.1 DATA: $T_{max} = 12.6\ kNm; PCD = 3D;\ \sigma_{c_{Bolt}} = 39\ MPa;$
$\tau_{Bolt} = 58\ MPa;\ \tau_{key} = 95\ MPa;\ \sigma_{c_{Key}} = 230\ MPa$

$For\ \ d_s = 95\ mm\ \ \rightarrow\ \ w = 0{,}028\ m\ and\ t = 0.016$✓

For Shearing

$Torque\ on\ shaft = Torque\ on\ key\ due\ to\ shear$

$Torque\ on\ shaft = w \times l \times \tau \times \frac{d}{2}$

$12600\ = 0{,}028 \times l \times 95 \times 10^6 \times \frac{0{,}095}{2}$✓

$l = \frac{12600\ \times 2}{0{,}028 \times 95 \times 10^6 \times 0{,}095}$ ✓

$l = 0{,}09972\ m$

$\boxed{l = 99{,}7\ mm}$✓

For Crushing

$Torque\ on\ shaft = Torque\ on\ key\ due\ to\ crushing$

$T = \frac{t}{2} \times l \times \sigma_c \times \frac{d}{2}$

$12600 = \frac{0,016}{2} \times l \times 230 \times 10^6 \times \frac{0,095}{2}$✓

$l = \frac{12600 \times 2 \times 2}{0,016(230 \times 10^6)(0,095)}$✓

$l = 0,14416\ m$✓

$\boxed{l = 144,2\ mm}$

Use Length is equal to 144,2 mm ✓ (8)

5.2 $PCD = 3D$

$PCD = 3(95)$

$PCD = \boxed{285\ mm}$✓ (1)

5.3 $Flange\ thickness = \frac{D}{4}$

$Flange\ thickness = \frac{95}{4}$

$= \boxed{23,75\ mm}$✓ (1)

[10]

QUESTION 6: STEAM ENGINE

6.1 $D = 820\ mm; P = 880\ kPa;\ \ L_{stroke} = 1,2\ m;\ \ L_k = 2\ m$

$F = P \times A$

$F = P \times \frac{\pi}{4} D^2$

$F = 880 \times 10^3 \times \frac{\pi}{4}(0,82)^2$✓

$F = \boxed{464,73\ kN}$✓ (2)

6.2 $\sin\theta = \frac{L_c}{L_k}$ $L_c = \frac{L_{stroke}}{2} = \frac{1,2}{2} = \boxed{0.6\ m}$✓

$\theta = \sin^{-1}\frac{0,6}{2}$✓

$\theta = \boxed{17,46°}$ ✓

$F_k = \frac{F_p}{\cos\theta}$

$F_k = \frac{464,73 \times 10^3}{\cos 17,46°}$ ✓

$F_k = \boxed{487,176\ kN}$✓ (5)

6.3 $F_{crank\ pin} = F_k$✓ $= 487,176\ kN$✓ (2)

6.4 $F_R = \tan\theta \times F_p$

$F_R = \tan 17,46° \times 464,73 \times 10^3$✓

$F_R = \boxed{146,17\ kN}$✓ (2)

6.5 $F_k = \tau \times 2 \times \frac{\pi}{4} {d_{pin}}^2$

$487,176 \times 10^3 = 35 \times 10^6 \times 2 \times \frac{\pi}{4} {d_{pin}}^2$✓

${d_{pin}}^2 = \frac{(487,176 \times 10^3) \times 4}{\pi(35 \times 10^6 \times 2)}$✓

$d_{pin} = \sqrt{\frac{(487,176 \times 10^3) \times 4}{\pi(35 \times 10^6 \times 2)}}$✓

$d_{pin} = 0,0942\ m$

$d_{pin} = \boxed{94,2\ mm}$✓ (4)

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6.6 $F_P = 0{,}75 \times \frac{\pi}{4} {d_{bolt}}^2 \times n \times \sigma_{bolt}$

$464{,}73 \times 10^3 = 0{,}75 \times \frac{\pi}{4} {d_{bolt}}^2 \times 20 \times 45 \times 10^6$✓

${d_{bolt}}^2 = \frac{(464{,}73 \times 10^3) \times 4}{\pi(0{,}75 \times 20 \times 45 \times 10^6)}$✓

$d_{bolt} = \sqrt{\frac{(464{,}73 \times 10^3) \times 4}{\pi(0{,}75 \times 20 \times 45 \times 10^6)}}$✓

$d_{bolt} = 0{,}0296\ m$✓

$d_{bolt} = 30\ mm$

$d_{bolt} = \boxed{M30}$✓ (5)

[20]

QUESTION 7: BELT DRIVES

7.1 $v = \frac{\pi(D+t)N}{60}$

$N = \frac{60v}{\pi(D+t)}$✓

$N = \frac{60(36)}{\pi(0{,}508+0{,}006)}$✓

$N = \boxed{1337{,}64\ rpm}$✓ (3)

7.2 $P = \frac{2\pi NT}{60}$

$T = \frac{60P}{2\pi N}$

$T = \frac{60(15 \times 10^3)}{2\pi(1337{,}64)}$✓

$T_{mean} = \boxed{107.08\ Nm}$✓ (2)

7.3 $T_{max} = 1{,}125 \times T_{mean}$

$T_{max} = 1{,}125 \times 107{,}08$✓

$T_{max} = \boxed{120{,}465\ Nm}$✓ (2)

7.4 $T_{max} = \frac{\pi}{16}(d^3)\tau$

$120{,}465 = \frac{\pi}{16}(d^3)41 \times 10^6$✓

$d^3 = \frac{16(120{,}465)}{\pi(41 \times 10^6)}$✓

$d^3 = 0{,}000014963$

$d = 0{,}02464\ m$

$d = \boxed{24{,}6\ mm}$

$Use\ d = 25\ mm\ (Std\ size)$ ✓ (3)

7.5 $\theta = \frac{265°}{57{,}3} = \boxed{4{,}625\ rads}$✓

$\frac{T_1}{T_2} = e^{\mu\theta}$

$\frac{T_1}{T_2} = e^{(0{,}2)(4{,}625)}$

$\frac{T_1}{T_2} = 2{,}522$

$T_1 = 2{,}522T_2$✓ ……(1)

$P = (T_1 - T_2)v$
$15 \times 10^3 = (T_1 - T_2)36$
$(2{,}522T_2 - T_2) = 416{,}67$✓

$T_2 = \frac{416{,}67}{1{,}522}$

$T_2 = \boxed{237{,}76\ N}$✓
$T_1 = 2{,}522(237{,}76)$
$T_1 = \boxed{600\ N}$✓ (5)
[15]

QUESTION 8: ULTIMATE AND WORKING STRESS FOR VARIOUS TYPE OF MATERIALS

8.1 *Explanation*:

To calculate allowable stress, divide **ultimate stress**✓ by **the factor of safety**✓

OR

$$Allowable\ Stress = \frac{Ultimate\ stress}{Factor\ of\ safety}$$ ✓✓ (2)

8.2 *Calculations*:

$$Allowable\ stress = \frac{300}{2}$$ ✓

$$Allowable\ stress = 150\ MPa$$ ✓ (2)

[4]

QUESTION 9: WELDED JOINTS

$t = 0{,}707t_1$
$t = 0{,}707(6)$ ✓
$t = \boxed{4{,}242\ mm}$ ✓

$A_{weld} = L_e \times t$
$A_{weld} = 0{,}06 \times 0{,}004242$ ✓
$A_{weld} = \boxed{0{,}00025452\ m^2}$ ✓

$\sigma = \frac{F}{A}$
$\sigma = \frac{36 \times 10^3}{0{,}00025452}$ ✓

$\sigma = 141442715{,}7\ Pa$
$\sigma = \boxed{141{,}4\ MPa}$ ✓ **[6]**

TOTAL: 100

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